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ENGINEERING CHANGE NOTICE

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1. ECN 634631

Proj. ECN

2. ECN Category (mark one)	3. Originator's Name, Organization, MSIN, and Telephone No.	4. USQ Required?	5. Date
Supplemental [X] Direct Revision ~~[X]~~ Change ECN [] Temporary [] Standby [] Supersedure [] Cancel/Void []	L. W. Shelton, NUH, H5-49, 376-6199	[] Yes [X] No	8/7/97
	6. Project Title/No./Work Order No. Tank 241-AW-103	7. Bldg./Sys./Fac. No. NA	8. Approval Designator NA
	9. Document Numbers Changed by this ECN (includes sheet no. and rev.) ~~WHC~~ ~~HNF~~-SD-WM-ER-455, Rev. 0	10. Related ECN No(s). NA	11. Related PO No. NA

12a. Modification Work	12b. Work Package No.	12c. Modification Work Complete	12d. Restored to Original Condition (Temp. or Standby ECN only)
[] Yes (fill out Blk. 12b) [X] No (NA Blks. 12b, 12c, 12d)	NA	NA Design Authority/Cog. Engineer Signature & Date	NA Design Authority/Cog. Engineer Signature & Date

13a. Description of Change   13b. Design Baseline Document? [] Yes [X] No

Add Appendix F, Evaluation to Establish Best-Basis Inventory for Double-Shell Tank 241-AW-103.

14a. Justification (mark one)

Criteria Change	[]	Design Improvement	[]	Environmental	[]	Facility Deactivation	[]
As-Found	[X]	Facilitate Const	[]	Const. Error/Omission	[]	Design Error/Omission	[]

14b. Justification Details

An effort is underway to provide waste inventory estimates that will serve as standard characterization source terms for the various waste management activities. As part of this effort, an evaluation of available information for double-shell tank 241-AW-103 was performed, and a best-basis inventory was established. This work follows the methodology that was established by the standard inventory task.

15. Distribution (include name, MSIN, and no. of copies)

Central Files	A3-88	K. M. Hall	R2-12
DOE Reading Room	H2-53	K. M. Hodgson	R2-11
TCSRC	R1-10	C. G. Brown	R2-12
File	H5-49		
L. W. Shelton	H5-49		
M. J. Kupfer	H5-49		
M. D. LeClair (3)	H0-50		

RELEASE STAMP

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16. Design Verification Required	17. Cost Impact				18. Schedule Impact (days)	
	ENGINEERING		CONSTRUCTION			
[] Yes	Additional	[] $	Additional	[] $	Improvement	[]
[X] No	Savings	[] $	Savings	[] $	Delay	[]

19. Change Impact Review: Indicate the related documents (other than the engineering documents identified on Side 1) that will be affected by the change described in Block 13. Enter the affected document number in Block 20.

SDD/DD	[]	Seismic/Stress Analysis	[]	Tank Calibration Manual	[]
Functional Design Criteria	[]	Stress/Design Report	[]	Health Physics Procedure	[]
Operating Specification	[]	Interface Control Drawing	[]	Spares Multiple Unit Listing	[]
Criticality Specification	[]	Calibration Procedure	[]	Test Procedures/Specification	[]
Conceptual Design Report	[]	Installation Procedure	[]	Component Index	[]
Equipment Spec.	[]	Maintenance Procedure	[]	ASME Coded Item	[]
Const. Spec.	[]	Engineering Procedure	[]	Human Factor Consideration	[]
Procurement Spec.	[]	Operating Instruction	[]	Computer Software	[]
Vendor Information	[]	Operating Procedure	[]	Electric Circuit Schedule	[]
OM Manual	[]	Operational Safety Requirement	[]	ICRS Procedure	[]
FSAR/SAR	[]	IEFD Drawing	[]	Process Control Manual/Plan	[]
Safety Equipment List	[]	Cell Arrangement Drawing	[]	Process Flow Chart	[]
Radiation Work Permit	[]	Essential Material Specification	[]	Purchase Requisition	[]
Environmental Impact Statement	[]	Fac. Proc. Samp. Schedule	[]	Tickler File	[]
Environmental Report	[]	Inspection Plan	[]		[]
Environmental Permit	[]	Inventory Adjustment Request	[]		[]

20. Other Affected Documents: (NOTE: Documents listed below will not be revised by this ECN.) Signatures below indicate that the signing organization has been notified of other affected documents listed below.

Document Number/Revision	Document Number/Revision	Document Number Revision
NA		

21. Approvals

	Signature	Date		Signature	Date
Design Authority			Design Agent		
Cog. Eng. M. J. Kupfer	M J Kupfer	8-28-97	PE		
Cog. Mgr. K. M. Hodgson	K. M. Hodgson	8-28-97	QA		
QA			Safety		
Safety			Design		
Environ.			Environ.		
Other C. J. Benar	MJ Kupfer per telecon for CJ Benar	8-28-97	Other		

DEPARTMENT OF ENERGY

Signature or a Control Number that tracks the Approval Signature

ADDITIONAL

Tank Characterization Report for Double-Shell Tank 241-AW-103

L. W. Shelton
Numatec Hanford Corporation, Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-96RL13200

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Key Words: TCR, best-basis inventory

Abstract: An effort is underway to provide waste inventory estimates that will serve as standard characterization source terms for the various waste management activities. As part of this effort, an evaluation of available information for double-shell tank 241-AW-103 was performed, and a best-basis inventory was established. This work follows the methodology that was established by the standard inventory task.

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RECORD OF REVISION

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Page 1

(2) Title
Tank Characterization Report for Double-Shell Tank 241-AW-103

CHANGE CONTROL RECORD

(3) Revision	(4) Description of Change - Replace, Add, and Delete Pages	Authorized for Release (5) Cog. Engr.	(6) Cog. Mgr. Date
0	(7) Initially released 7/13/95 on EDT 612550.	K. M. Hodgson	J. G. Kristofzski
RS 0A	Incorporate per ECN-634631.	M. J. Kupfer	K. M. Hodgson
		MJKupfer 8-28-98	K.M.Hodgson 8-28-98

A-7320-005 (08/91) WEF168

APPENDIX F

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR DOUBLE-SHELL TANK 241-AW-103

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APPENDIX F

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR DOUBLE-SHELL TANK 241-AW-103

An effort is underway to provide waste inventory estimates that will serve as standard characterization source terms for the various waste management activities (Hodgson and LeClair 1996). As part of this effort, an evaluation of available information for double-shell tank 241-AW-103 was performed, and a best-basis inventory was established. This work, detailed in the following sections, follows the methodology that was established by the standard inventory task.

F1.0 CHEMICAL INFORMATION SOURCES

Available composition information for tank 242-AW-103 is as follows:

- This tank characterization report (TCR) for tank 241-AW-103 provides characterization results for the sludge from the 1989 core sampling event and the 1994 grab sampling event which provides results for the supernatant. Table 4-3 in this TCR summarizes the results from the statistical analysis of data from both sample events.
- Teats (1982) provides characterization data on the double-shell slurry feed (DSSF) heel in tank 241-AW-103.
- Schofield (1991) provides tank content estimates based on a reconciliation of flowsheet records, process tests, and the 1989 core sample.
- The Hanford Defined Waste (HDW) model document (Agnew et al. 1997) provides tank content estimates derived from the HDW model, in terms of component concentrations and inventories.

F2.0 COMPARISON OF COMPONENT INVENTORY VALUES

Sample-based inventories derived from analytical concentration data, and HDW model inventories (Agnew et al. 1997), are compared in Tables F2-1 and F2-2.

The chemical species are reported without charge designation per the best-basis inventory convention.

Table F2-1. Sample-Based and Hanford Defined Waste Model-Based Inventory Estimates for Nonradioactive Components in tank 241-AW-103. (2 Sheets)

Analyte	Sampling inventory estimate[a] (kg)	HDW model inventory estimate (kg)	Analyte	Sampling inventory estimate[a] (kg)	HDW model inventory estimate (kg)
Ag	923	NR	NO_2	702	1,030
Al	12,100	40.0	NO_3	200,000	49,400
As	<686	NR	OH	22,800	121,000
Ba	754	NR	oxalate	NR	.00107
Be	78.4	NR	Pb	<157	0.609
Bi	739	0.222	Pd	NR	NR
Ca	1,730	5,540	PO_4	33.4	267
Ce	2,210	NR	Pt	NR	NR
Cd	<2,160	NR	Rh	<176	NR
Cl	77.7	345	Ru	<1,630	NR
Co	<58.8	NR	Sb	98.0	NR
Cr	3,040	20.9	Si	31,900	2.12
Cu	65.6	NR	SO_4	32.4	36.8
F	127,000	142,000	Sr	39.2	0
Fe	1,580	28,000	Te	<588	NR
formate	NR	NR	TIC as CO_3	16,600	8,570
Hg	NR	580	TOC	538	33.4
K	21,900	17,600	U_{total}	18,400	13,900
La	1,650	0.00128	V	<19.6	NR
Mg	1,180	NR	W	NR	NR
Mn	517	13.1	Zn	161	NR
Na	281,000	184,000	Zr	200,000	116,000
Nd	NR	NR	H2O (wt%)	51.2[b]	75.5

Table F2-1. Sample-Based and Hanford Defined Waste Model-Based Inventory Estimates for Nonradioactive Components in tank 241-AW-103. (2 Sheets)

Analyte	Sampling inventory estimate[a] (kg)	HDW model inventory estimate (kg)	Analyte	Sampling inventory estimate[a] (kg)	HDW model inventory estimate (kg)
NH_3	NR	26,400	density (kg/L)	1.30[b]	1.17
Ni	343	4.50			

HDW = Hanford Defined Waste
NR = Not reported
[a]Section 4 of this TCR.
[b]Mass weighted average of sludge and supernate.

Table F2-2. Sample-Based and Hanford Defined Waste Model-Based Inventory Estimates for Radioactive Components in Tank 241-AW-103.

Analyte[a]	Sampling inventory estimate (Ci)	HDW model inventory estimate (Ci)	Analyte	Sampling inventory estimate (Ci)	HDW model inventory estimate (Ci)
^{14}C	1.25	0.532	^{154}Eu	NR	58.9
^{90}Sr	18,900	10,000	^{237}Np	<0.882	0.0317
^{99}Tc	180	2.31	$^{239/240}Pu$	1,350	1,760
^{129}I	NR	0.00462	^{241}Am	238	39.1
^{137}Cs	128,000	11,900	^{238}Pu	43.7	167

HDW = Hanford Defined Waste
NR = Not reported.
[a]Sample-based radionuclide inventories decayed to July 1, 1995. HDW model radionuclide inventories are baselined to January 1, 1994.

F3.0 COMPONENT INVENTORY EVALUATION

F3.1 CONTRIBUTING WASTE TYPES

Tank 241-AW-103 first received double-shell slurry feed (DSSF) in 1980 from 242-A Evaporator Campaigns 80-8, 80-10, and 81-1. The DSSF from campaigns 80-10 and 81-1 were initially sent to other tanks where solids were allowed to settle before being transferred to tank 241-AW-103. After most of the DSSF supernatant was pumped out of tank 241-AW-103, leaving a DSSF heel, tank 241-AW-103 began receiving neutralized cladding removal waste (NCRW) from the plutonium-uranium extraction (PUREX) Plant. Tank 241-AW-103 continued to receive transfers of NCRW from 1983 through 1988. Recently, tank 241-AW-103 has received small amounts of miscellaneous PUREX wastes with low solids content.

The HDW model (Agnew et al. 1997) estimates that 2.08 E+07 L of CWZr2 was sent to the two NCRW waste tanks (241-AW-103 and 241-AW-105). The PUREX Flowsheet for Reprocessing N Reactor Fuels (RHO 1982) and fuel discharge records indicate that 1.74 E+07 L of NCRW was transferred (3920 MTU processed at 4,427 L/MTU). Schofield (1991) indicates that the waste volume may have been slightly higher (1.87 E+07L).

Expected solids in waste

Agnew et. al. (1997): Zircaloy[1] decladding waste (CWZr2) (Referred to in this report as NCRW).

F3.2 EVALUATION OF TECHNICAL FLOWSHEET INFORMATION

The waste composition of NCRW from flowsheets and process knowledge are provided in Table F3-1 along with the comparative HDW stream from Agnew et al. (1997) and the DSSF composition for the 80-8 242A Evaporator Campaign (Teats 1982). The flowsheet composition is taken from Schofield (1991). Schofield used the PUREX Flowsheet for Reprocessing N Reactor Fuels (RHO 1982) plus his knowledge of the process as it actually operated to develop his composition. He adjusted some flowsheet values, e.g. NaOH which was frequently added in excess for neutralization. He also included estimates of actinides and fission products in addition to corrosion products, i.e., Fe, Cr, and Ni. The source of the HDW model composition is unknown.

[1]Zircaloy is a registered trademark of Teledyne Wah Chang, Albany, Oregon.

F3.2.1 Predicted Waste Inventories

Because of the many observed differences among the inventory values in Table F2-1 and F2-2 an evaluation was performed to help identify potential errors and/or missing information that could influence the sample-based inventories and/or the inventories estimated by the HDW model. Reference inventories, based on a set of simplified assumptions, were established and compared with the sample- and HDW-based inventories. The following assumptions and observations were used to generate these reference inventories:

- The volume of NCRW sent to underground storage is 1.74 E+07 L based on the PUREX Flowsheet for Processing N Reactor Fuels. This volume is based on the flowsheet and the wastes processed and corresponds to the flowsheet chemical concentrations.

- Tank waste mass is calculated using a specific gravity of 1.43 for the sludge, 1.00 for the supernatant and the volumes listed in Hanlon (1997).

  Supernate volume: 564L (149 Kgal)
  Sludge volume: 1,374L (363 Kgal)

- The NCRW waste stream and DSSF from the 80-8 242-A Evaporator campaign contributed to sludge formation.

- No radiolysis of NO_3 to NO_2 and no addition of NO_2 to the waste for corrosion purposes are factored into this assessment.

- All Fe and Zr precipitate.

- Cr, F, K, Na, Ni, and OH partition between the liquid and solid phases.

- All NO_2 and NO_3 remains dissolved in the interstitial liquid and supernatant.

Table F3-1. Technical Flowsheet and Los Alamos National Laboratory Hanford Defined Waste Streams. (2 Sheets)

Analyte	Flowsheet NCRW[a] (*M*)	HDW model CWZr2[b] (*M*)	80-8 Evaporator Campaign DSSF[c] (*M*)
Al	NR	0	1.47
NO_3	0.024	0.3875	3.19
NO_2	0.011	0.007	2.12
Fe	0.00206[d]	0.04	NR
Cr	7.74 E-04[d]	0	NR
Ni	3.62 E-04[d]	0	NR
Zr	0.18	0.1	NR
Na	1.634	1.0176	NR
Ca	NR	0.018	NR
OH	0.72	0.637	2.57
CO_3	NR	0.018	0.318
PO_4	NR	0	0.115
F	1.36	0.77	NR
Cl	NR	0.0046	NR
Hg	NR	0.00023	NR
K	0.47	0.221	NR
NH_3	NR	0.77	NR
TOC	NR	NR	12.2 g/L
U	NR	0.00777	NR
$^{239/240}Pu$ Ci/L	NR	1.44 E-04	NR
^{137}Cs Ci/L	NR	0.00576	0.474
^{90}Sr Ci/L	NR	0.00488	0.0132
Total volume sent to waste tanks (L)	1.74 E+07	2.08 E+07	NA

Table F3-1. Technical Flowsheet and Los Alamos National Laboratory Hanford Defined Waste Streams. (2 Sheets)

Analyte	Flowsheet NCRW[a] (*M*)	HDW model CWZr2[b] (*M*)	80-8 Evaporator Campaign DSSF[c] (*M*)

CWZr2 = HDW model designation for NCRW
DSSF = Double-shell slurry feed
HDW = Hanford Defined Waste
NCRW = Neutralized cladding removal waste
NA = Not applicable
NR = Not reported
[a] Schofield (1991), Table B-6.
[b] Agnew et al. (1997), CWZr2 waste type in Appendix B
[c] Teats (1982), Table 4
[d] These are equivalent flowsheet compositions derived from fuel cladding composition and estimates of corrosion rates (Schofield 1991, Table B-9).

The waste constituants sent to tank 241-AW-103 can be estimated from the NCRW flowsheet and HDW model compositions and the waste volume transferred. Koreski (1996) has determined that 63 percent of the NCRW was transferred to tank 241-AW-103 (1.10 E+07 L). The HDW model predicts that 1.31 E+07 L of NCRW was transferred to tank 241-AW-103.

Table F3-2. Estimated Total Waste Constituents Sent to Tank 241-AW-103 in Neutralized Cladding Removal Waste[a]. (2 Sheets)

Analyte	Flowsheet NCRW[b] (MT)	HDW Model CWZr2[c] (MT)
NO_3	16.3	315
NO_2	5.55	4.22
Fe	1.59	29.3
Cr	0.44	0
Ni	0.23	0
Zr	1.67[d]	120
Na	412	307
Ca	NR	9.45
OH	134	142
CO_3	NR	14.2

Table F3-2. Estimated Total Waste Constituents Sent to Tank 241-AW-103 in Neutralized Cladding Removal Waste[a]. (2 Sheets)

Analyte	Flowsheet NCRW[b] (MT)	HDW Model CWZr2[c] (MT)
F	283	192
Cl	NR	1.63
Hg	NR	0.081
K	201	78.1
NH_3	NR	272
U	NR	2.75
$^{239/240}Pu$ (Ci)	NR	1,890
^{137}Cs (Ci)	NR	75,500
^{90}Sr (Ci)	NR	64,000

CWZr2 = HDW model inventory for NCRW waste
HDW = Hanford Defined Waste
NCRW = Neutralized cladding removal waste
NR = Not reported

[a] Based on a volume of 1.10 E+07 L (4,135 L/MTU) and 63 percent of the 3,920 MTU processed).

[b] Schofield (1991).

[c] Agnew et al. (1997), based on 1.31 E+07 L CWZr2 waste from waste transaction records, radionuclides decayed to January 1, 1994

[d] The flowsheet prediction is actually 180 MT based on the 0.18 molar concentration in NCRW. However, the quantity of zirconium sent to tank 241-AW-103 can be more accurately estimated from the zirconium associated with the fuel elements processed (167 MT).

F3.2.2 Volume Ratio DSSF:NCRW in the Sludge.

The HDW model (Agnew et al. 1997) does not predict any DSSF remained in tank 241-AW-103. A comparison of the component concentrations in the lower segments of the 1989 core sample with those in the upper segments suggest otherwise. Tables B-1 through B-4 of this TCR indicate that the concentrations of Al, Cr, PO_4, Na, OH, and NO_3 are much higher in the composite of Segments 6 through 10 than Segments 4 and 5. These are the components that usually comprise the bulk of DSSF.

One way to estimate the volume of the DSSF heel in tank 241-AW-103 is to estimate the number of segments in the composite of Segments 6 through 10 that represent DSSF. This can be done by using the component concentrations of the DSSF that entered the tank, assuming the volume of the composite not occupied by DSSF has the same concentrations as the NCRW segments (Segments 4 and 5), and adjusting the relative proportions of both layers until the calculated concentrations approach the reported average analytical concentrations for the entire composite.

For example, the DSSF concentration for Al in Table F3-1 is 1.47*M* and the analytical average result for Segments 4 and 5 is 0.128*M*. The average Al concentration for the composite of Segments 6 through 10 is 0.367*M*. Assuming that one of the five segments in the composite is representative of DSSF, the calculation would be:

$$\frac{(1\ \mathrm{seg})(1.47M) + (4\ \mathrm{seg})(0.128M)}{(5\ \mathrm{seg})} = 0.396M$$

which is 8 percent higher than the reported value of 0.367*M*.

The best results are achieved when the DSSF heel is assumed to be equivalent to 0.90 segments, or

(0.90 segment)*(19 in./segment)*(2,750 gal/in.)*(3.785 L/gal) = 178,000 L.

The calculated composite concentrations are compared with the analytical composite concentrations in Table F3-3.

Table F3-3. Calculated and Reported Analytical Concentrations for Partial Core Composite.[a] (2 Sheets)

Analyte	Calculated composite (*M*)[a] for Segments 6-10	Analytical composite (*M*)[b]
Al	0.37	0.367
OH	0.99	1.01
NO_3	0.64	3.23
CO_3	0.26	0.142
PO_4	0.036	0.052
$^{239/240}Pu$[c] (Ci/L)	1.64 E-03	6.31 E-04
^{137}Cs[c] (Ci/L)	0.116	0.112

Table F3-3. Calculated and Reported Analytical Concentrations for Partial Core Composite.[a] (2 Sheets)

Analyte	Calculated composite (M)[a] for Segments 6-10	Analytical composite (M)[b]
$^{90}Sr^{c}$ (Ci/L)	0.020	0.014

NR = Not reported.

[a] Based on the assumption that the DSSF heel occupies 178,000 L of the sludge volume (0.90 fraction of a core segment).

[b] Calculated from mean composite data in Appendix B assuming a density of 1.43 g/mL

[c] Radionuclides reported as of sample analysis date.

F3.2.3 Predicted Solids Concentration Factor for NCRW Waste

The concentration factor (CF) is defined as the ratio of the concentration of a component precipitated from the solution as indicated by the analytical data versus the concentration of that component in the original waste stream. It is assumed that all Zr in the NCRW waste stream precipitates and settles in the receiver tank. Thus, Zr can be used to determine what the CF for NCRW waste is for tank 241-AW-103.

The Zr concentration in the sludge is reported to be 1.60M corresponding to 200 MT of Zr. Schofield (1991) established total Zr in the cladding waste sent to underground storage to be 265 MT. The total amount of zirconium in the NCRW waste is believed to be accurate because the amount of fuel charged to PUREX and the amount of Zr per MTU of fuel are known with a high level of confidence.

If the sampling data are correct then 75 percent of the total Zr is in tank 241-AW-103. However, waste transfer data records show that only 63 percent of the NCRW went to tank 241-AW-103 (Koreski 1996). On this basis, 167 MT of Zr would be in tank 241-AW-103 and 98 MT would be in tank 241-AW-105. The sample data taken from the TCR for tank 241-AW-105 (Simpson 1995) suggest that 384 MT of Zr are to be found in that tank. This amount, combined with the 200 MT of Zr in tank 241-AW-103 add up to 584 MT of Zr. This is clearly not possible based on the flowsheet and fuel discharge records. The analytical Zr concentration reported for the two tanks appear to be biased high.

Since transfer records suggest that 63 percent of the NCRW waste was sent to tank 241-AW-103, 167 MT of Zr was assigned to that tank which corresponds to a Zr sludge concentration of 1.34M used in this evaluation. The flowsheet concentration is 0.18M Zr.

The CF_{Zr} resulting from these concentrations is:

$$\frac{1.34 \text{ moles Zr/L}}{0.18 \text{ moles Zr/L per flowsheet}} = 7.44$$

Iron is another component expected to precipitate 100 percent. Based on an equivalent flowsheet Fe concentration of 0.00206 (Schofield 1991) and a sludge concentration of 0.0206*M*, the CF_{Fe} is 10. This is 34 percent higher than the CF_{Zr}. However, instead of averaging these numbers, the CF_{Zr} was chosen because there is a higher degree of confidence in the Zr flowsheet and sludge concentrations.

F3.2.4 Estimate of Partitioning Factors for Components Assumed to Partition between Aqueous and Solid Phases

Concentration factors for components not expected to precipitate 100 percent can be ratioed to CF_{Zr} to obtain the partitioning factors for those components. The PF for any component N, defined as CF_N/CF_{Zr}, is the fraction of N partitioned to the sludge. The PFs can be multiplied by the amount sent to the tanks as indicated by the flowsheet to estimate the amount partitioned to the sludge. The supernatant in tank 241-AW-103 was periodically removed, so the NCRW waste remaining in the tank is essentially the waste that partitioned to the sludge.

Five analytes in the tank 241-AW-103 waste (Zr, Fe, K, F, and OH) result primarily from the NCRW waste stream. Zirconium and iron are insoluble and partition completely to the sludge layer. The partition factors for K, F, and OH can be estimated from the sample data for segments 4 and 5 which are relatively uncontaminated and undiluted by the DSSF layer. The partition factors are provided in Table F3-4.

Table F3-4. Partition Factors for Potassium, Fluoride and Hydroxide.

Analyte	Concentration segments 4-5 (μg/g)	Concentration segments 4-5 (molar)[a]	PUREX flowsheet concentration (molar)[b]	Concentration factor[c]	Partition factor[d]
K	15,600	0.571	0.47	1.21	0.163
F	52,100	3.92	1.36	2.88	0.388
OH	7,660	0.644	0.72	0.895	0.120

[a] Calculated using density of 1.43 g/mL.
[b] From Table F3-1.
[c] Segment concentration divided by the flowsheet concentration.
[d] The concentration factor of the analyte divided by the concentration factor of zirconium (7.44).

The NCRW sludge inventories expected for the five analytes based on the NCRW flowsheet can then be calculated and compared to the HDW model and sample-based inventories (Table F3-5).

Table F3-5. Comparison of Tank 241-AW-103 Sludge Layer Inventory Estimates

Analyte	NCRW flowsheet prediciton[a] (MT)	HDW model CWZr2 inventory[b] (MT)	Sample-based inventory (MT)
Zr	167	116	200
Fe	1.59	27.9	1.58
K	32.9[c]	10.3	21.9
F	110[c]	138	117
OH	16.1[c]	NA[d]	21

HDW = Hanford Defined Waste
NCRW = Neutralized cladding removal waste
CWZr2 = HDW model designation for NCRW
[a] Table F-2
[b] Agnew et al. (1997).
[c] Due to the use of sample data in the determination of the partition factors, these estimates are not entirely independent of the sample inventory estimate. Table F3-2 multiplied by partition factor.
[d] The total hydroxide reported by the HDW model would not be comparable to the free hydroxide predicted from the NCRW flowsheet or waste samples.

Sludge inventories calculated from the flowsheet agree more closely to the sampling results than the HDW model does. The zirconium and iron inventories predicted from the PUREX flowsheet in particular are a much better match for the sampling inventory estimate than the HDW model prediction. The results tend to validate the sample-base inventory estimate.

F3.3 PREDICTED SUPERNATANT COMPONENT INVENTORIES

Sample-based inventories for the supernatant in tank 241-AW-103, derived from the 1994 sampling event and the HDW model supernatant estimates, are compared in Table F3-6.

Table F3-6. Sample-Based and Hanford Defined Waste Model-Based Inventory Estimates for Nonradiocative Components in the Tank 241-AW-103 Supernatant.

Analyte	Sampling[a] inventory estimate (MT)	HDW model[b] estimate (MT)	Analyte	Sampling[a] inventory estimate (MT)	HDW model[b] estimate (MT)
Al	0.0239	0.040	NO_2	0.702	0.448
Bi	NR	2.22 E-04	NO_3	2.02	21.2
Ca	NR	0.317	OH	1.85	1.77
Cl	0.0777	0.151	oxalate	NR	1.07 E-06
Cr	NR	0.0209	Pb	NR	6.09 E-04
F	10.0	3.81	PO_4	0.0334	0.267
Fe	<0.00118	0.0981	Si	NR	0.00212
formate	NR	NR	SO_4	0.0324	0.0368
Hg	NR	0.00168	Sr	NR	0
K	NR	7.34	CO_3	2.65	0.746
La	NR	1.28 E-06	TOC	0.538	0.0337
Mn	NR	0.0131	U	NR	0.834
Na	11.3	10.3	Zr	NR	0.228
Ni	NR	0.0045	NH_3	NR	11.1

HDW = Hanford Defined Waste
NR = Not reported.
[a] Table 4-3
[b] Agnew et al. (1997).

There are major differences in the analytical-based inventories and the inventories estimated in the HDW model. The HDW model predicts that 95.1 percent of the supernatant in tank 241-AW-103 at the end of 1994 came from NCRW waste with the balance coming from miscellaneous PUREX (4.5 percent) and other wastes (0.3 percent). Thus, the HDW model supernatant concentration is derived from an overall NCRW composition already shown to be highly suspect. Analytical data for the liquid phase, on the other hand, usually display high precision and accuracy. For these reasons, the analytical values are assumed to be correct.

F3.4 COMMENTS ON ANALYTES

Aluminum. The flowsheet and the HDW model predict little Al to be present in the waste, while the sample data for tank 241-AW-103 indicate 12.1 MT of Al, the bulk being in the sludge. Schofield (1991) mentions that some of the Al likely came from ANN used in the fuel dissolution step and the remainder from impurities or dirt. However, he wasn't aware of the aluminum-rich DSSF heel which probably accounts for most of the disparity.

Zirconium. The amount of Zr in NCRW predicted by the flowsheet and fuel discharge records is accurately known. The fraction of NCRW sent to tank 241-AW-103 is also accurate. The sample result, 200 MT, is larger than the calculated amount by 20 percent. The calculated value (167 MT) is considered to be the correct inventory.

Sodium. Due to the lack of analytical data for the DSSF heel,it was not possible to determine sodium partitioning for tank 241-AW-103. The sample-based inventory will be assumed to be correct.

Chromium. Since the data on the DSSF heel do not include chromium as an analyte, a proper reconciliation could not be done. The sample-based inventory will be assumed to be correct..

Fluoride. For the sludge, the sample-based inventory agrees more closely with this evaluation than the HDW model estimate. The sampling estimate is 6 percent higher than the amount calculated in this evaluation but 15 percent lower than the HDW model prediction. The sample-based fluoride inventory will be used as the best-basis.

Nitrate. The flowsheet nitrate concentration is 0.024*M* and the nitrate concentration in the 43.1-cm (17-in.) DSSF heel is predicted to be 3.19*M*. The weighted average sample-based nitrate concentration in the sludge is 2.33*M*. From the sampling data, the nitrate in the lower segments is almost 40 times more concentrated where the DSSF heel is than the top where only NCRW solids are expected to be. However, the DSSF heel could not alone account for the higher NO_3 concentrations. The sample results are assumed to be valid.

F4.0 DEFINE THE BEST-BASIS AND ESTABLISH COMPONENT INVENTORIES

Information about chemical, radiological, and/or physical properties is used to perform safety analyses, engineering evaluations, and risk assessment associated with waste management activities, as well as regulatory issues. These activities include overseeing tank farm operations and identifying, monitoring, and resolving safety issues associated with these operations and with the tank wastes. Disposal activities involve designing equipment, processes and facilities for retrieving wastes and processing them into a form that is suitable for long-term storage.

Chemical and radiological inventory information are generally derived using three approaches: (1) component inventories are estimated using the results of sample analyses, (2) component inventories are predicted using the HDW Model based on process knowledge and historical information, or (3) a tank-specific process estimate is made based on process flowsheets, reactor fuel data, essential material usage, and other operating data.

An effort is underway to provide waste inventory estimates that will serve as standard characterization source terms for the various waste management activities (Hodgson and LeClair 1996). As part of this effort, an evaluation of chemical information for tank 241-AW-103 was performed, and a best basis inventory was established. The results of this evaluation support using sample data, with some exceptions for the best-estimate inventory for tank 241-AW-103 for the following reasons.

1. Data from the 1989 core sample display good precision. The core sample recovery was adequate.

2. The results from the independent assessment evaluation compare favorably with the sample-based data.

Once the best-basis inventories were determined, the hydroxide inventory was calculated by performing a charge balance with the valence of other analytes. In some cases, this approach requires that other analyte (e.g., sodium or nitrate) inventories be adjusted to achieve the charge balance. During such adjustments, significant figures are retained. This charge balance approach is consistent with that used by Agnew et al. (1997). In order to charge balance the supernate potassium was added. The pressence of potassium is consistent with samples taken in 1989 (Tingey et al. 1990).

Best-basis tank inventory values are derived for 46 key radionuclides (as defined in Section 3.1 of Kupfer et al. 1997), all decayed to a common report date of January 1, 1994. Often, waste sample analyses have only reported ^{90}Sr, ^{137}Cs, $^{239/240}$Pu, and total uranium (or total beta and total alpha), while other key radionuclides such as ^{60}Co, ^{99}Tc, ^{129}I, ^{154}Eu, ^{155}Eu, and ^{241}Am, etc., have been infrequently reported. For this reason it has been necessary to derive most of the 46 key radionuclides by computer models. These models estimate radionuclide activity in batches of reactor fuel, account for the split of radionuclides to various separations plant waste streams, and track their movement with tank waste transactions. (These computer models are described in Kupfer et al. 1997, Section 6.1 and in Watrous and Wootan 1997.) Model generated values for radionuclide concentrations in any of 177 tanks are reported in the HDW Rev. 4 model results (Agnew et al. 1997). The best-basis value for any one analyte may be either a model-based result or a sample or engineering assessment-based result if available. (No attempt has been made to ratio or normalize model results for all 46 radionuclides to separate phases or when values for measured nuclides disagree with the model.) For a discussion of typical error between model derived values and sample derived values, see Kupfer et al. 1997, Section 6.1.10.

Best-basis inventory estimates for tank 241-AW-103 are presented in Tables F4-1 through F4-6. Only those analytes detected by the various laboratory procedures are included in these tables. The inventory values reported in Tables F4-1 through F4-6 are subject to change. Refer to the Tank Characterization Database (TCD) for the most current inventory values.

Table F4-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-AW-103 Supernatant (Effective November 30, 1996).

Analyte	Supernatant inventory (kg)	Basis (S, M, E, or C)[1]	Comment
Al	23.9	S	
Bi	NR		
Ca	NR		
Cl	77.7	S	
TIC as CO_3	2,650	S	
Cr	NR		
F	10,000	S	
Fe	<1.18	S	
K	11,600	C	
La	NR		
Mn	NR		
Na	11,300	S	
Ni	NR		
NO_2	702	S	
NO_3	2,020	S	
OH	1,850	S	
Pb	NR		
PO_4	33.4	S	
Si	NR		
SO_4	32.4	S	
Sr	NR		
TOC	538	S	
U_{TOTAL}	NR		
Zr	NR		

[1]S = Sample-based
M = Hanford Defined Waste model-based (Agnew et al. 1997)
E = Engineering assessment-based
C = Calculated by charge balance; includes oxides as hydroxides, not including CO_3, NO_2, NO_3, PO_4, SO_4, and SiO_3
NR = Not reported.

Table F4-2. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-AW-103 Supernatant Decayed to January 1, 1994 (Effective November 30, 1996). (2 Sheets)

Analyte	Total inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{3}H	NR		
^{14}C	NR		
^{59}Ni	NR		
^{60}Co	NR		
^{63}Ni	NR		
^{79}Se	NR		
^{90}Sr	0.129	S	
^{90}Y	0.129	S	Referenced to ^{90}Sr
^{93}Zr	NR		
^{93m}Nb	NR		
^{99}Tc	NR		
^{106}Ru	NR		
^{113m}Cd	NR		
^{125}Sb	NR		
^{126}Sn	NR		
^{129}I	NR		
^{134}Cs	NR		
^{137}Cs	12,200	S	
^{137m}Ba	11,500	S	Referenced to ^{137}Cs
^{151}Sm	NR		
^{152}Eu	NR		
^{154}Eu	NR		
^{155}Eu	NR		
^{226}Ra	NR		
^{227}Ac	NR		
^{228}Ra	NR		
^{229}Th	NR		

Table F4-2. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-AW-103 Supernatant Decayed to January 1, 1994 (Effective November 30, 1996). (2 Sheets)

Analyte	Total inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{231}Pa	NR		
^{232}Th	NR		
^{232}U	NR		
^{233}U	NR		
^{234}U	NR		
^{235}U	NR		
^{236}U	NR		
^{237}Np	NR		
^{238}Pu	NR		
^{238}U	NR		
$^{239/240}Pu$	<0.00667	S	
^{240}Pu	NR		
^{241}Am	<0.968	S	
^{241}Pu	NR		
^{242}Cm	NR		
^{242}Pu	NR		
^{243}Am	NR		
^{243}Cm	NR		
^{244}Cm	NR		

[1]S = Sample-based
M = Hanford Defined Waste model-based (Agnew et al. 1997)
E = Engineering assessment-based
NR = Not reported.

Table F4-3. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-AW-103 Sludge (Effective November 30, 1996).

Analyte	Sludge inventory (kg)	Basis (S, M, or E)[1]	Comment
Al	12,100	S	
Bi	NR		
Ca	1,730	S	
Cl	NR	S	
TIC as CO_3	14,000	S	
Cr	3,040	S	
F	117,000	S	
Fe	1,580	S	
K	21,900	S	
La	1,650	S	
Mn	517	S	
Na	270,000	S	
Ni	343	S	
NO_2	NR	S	
NO_3	198,000	S	
OH	166,000	C	
Pb	<157	S	
PO_4	NR	S	
Si	31,900	S	
SO_4	NR	S	
Sr	39.2	S	
TOC	NR	S	
U_{TOTAL}	18,400	S	
Zr	167,000	E	

[1]S = Sample-based
M = Hanford Defined Waste model-based (Agnew et al. 1997)
E = Engineering assessment-based
C = Calculated by charge balance; includes oxides as hydroxides, not including CO_3, NO_2, NO_3, PO_4, SO_4, and SiO_3.
NR = Not reported.

Table F4-4. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-AW-103 Sludge Decayed to January 1, 1994 (Effective November 30, 1996). (2 Sheets)

Analyte	Total inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{3}H	NR		
^{14}C	1.25	S	
^{59}Ni	NR		
^{60}Co	NR		
^{63}Ni	NR		
^{79}Se	NR		
^{90}Sr	19,600	S	
^{90}Y	19,600	S	Referenced to ^{90}Sr
^{93}Zr	NR		
^{93m}Nb	NR		
^{99}Tc	180	S	
^{106}Ru	NR		
^{113m}Cd	NR		
^{125}Sb	NR		
^{126}Sn	NR		
^{129}I	NR		
^{134}Cs	NR		
^{137}Cs	120,000	S	
^{137m}Ba	114,000	S	Referenced to ^{137}Cs
^{151}Sm	NR		
^{152}Eu	NR		
^{154}Eu	NR		
^{155}Eu	NR		
^{226}Ra	NR		
^{227}Ac	NR		
^{228}Ra	NR		
^{229}Th	NR		

Table F4-4. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-AW-103 Sludge Decayed to January 1, 1994 (Effective November 30, 1996). (2 Sheets)

Analyte	Total inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{231}Pa	NR		
^{232}Th	NR		
^{232}U	NR		
^{233}U	NR		
^{234}U	NR		
^{235}U	NR		
^{236}U	NR		
^{237}Np	<0.882	S	
^{238}Pu	44.2	S	
^{238}U	NR		
$^{239/240}Pu$	1,350	S	
^{240}Pu	NR		
^{241}Am	238	S	
^{241}Pu	NR		
^{242}Cm	NR		
^{242}Pu	NR		
^{243}Am	NR		
^{243}Cm	NR		
^{244}Cm	NR		

[1]S = Sample-based
M = Hanford Defined Waste model-based (Agnew et al. 1997)
E = Engineering assessment-based
NR = Not reported.

Table F4-5. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-AW-103 (Effective November 30, 1996).

Analyte	Total inventory (kg)	Basis (S, M, or E)[1]	Comment
Al	12,100	S	
Bi	0.222	M	
Ca	1,730	S	
Cl	77.7	S	
TIC as CO_3	16,600	S	
Cr	3,040	S	
F	127,000	S	
Fe	1,580	S	
Hg	580	M	
K	33,500	S	
La	1,650	S	
Mn	517	S	
Na	282,000	S	
Ni	343	S	
NO_2	702	S	
NO_3	200,000	S	
OH	168,000	C	
Pb	<157	S	
PO_4	33.4	S	
Si	31,900	S	
SO_4	32.4	S	
Sr	39.2	S	
TOC	538	S	
U_{TOTAL}	18,400	S	
Zr	167,000	E	

[1]S = Sample-based
M = Hanford Defined Waste model-based (Agnew et al. 1997)
E = Engineering assessment-based
C = Calculated by charge balance; includes oxides as hydroxides, not including CO_3, NO_2, NO_3, PO_4, SO_4, and SiO_3.
NR = Not reported.

Table F4-6. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-AW-103 Decayed January 1, 1994 (Effective November 30, 1996). (2 Sheets)

Analyte	Total inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{3}H	41.3	M	
^{14}C	1.25	S	
^{59}Ni	0.196	M	
^{60}Co	7.84	M	
^{63}Ni	22.7	M	
^{79}Se	0.0665	M	
^{90}Sr	19,600	S	
^{90}Y	19,600	S	Referenced to ^{90}Sr
^{93}Zr	0.321	M	
^{93m}Nb	0.140	M	
^{99}Tc	180	S	
^{106}Ru	710	M	
^{113m}Cd	3.37	M	
^{125}Sb	189	M	
^{126}Sn	0.105	M	
^{129}I	0.00462	M	
^{134}Cs	83.9	M	
^{137}Cs	132,000	S	
^{137m}Ba	125,000	S	Referenced to ^{137}Cs
^{151}Sm	230	M	
^{152}Eu	1.53	M	
^{154}Eu	58.9	M	
^{155}Eu	277	M	
^{226}Ra	6.53 E-07	M	
^{227}Ac	3.88 E-06	M	
^{228}Ra	3.32 E-04	M	
^{229}Th	7.73 E-06	M	

Table F4-6. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-AW-103 Decayed January 1, 1994 (Effective November 30, 1996). (2 Sheets)

Analyte	Total inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{231}Pa	2.07 E-05	M	
^{232}Th	2.81 E-05	M	
^{232}U	0.00282	M	
^{233}U	0.0051	M	
^{234}U	6.73	M	
^{235}U	0.256	M	
^{236}U	0.554	M	
^{237}Np	<0.882	S	
^{238}Pu	44.2	S	
^{238}U	4.62	M	
$^{239/240}$Pu	1,350	S	
^{241}Am	238	S	
^{241}Pu	17,000	M	
^{242}Cm	0.134	M	
^{242}Pu	0.0635	M	
^{2243}Am	0.00822	M	
^{243}Cm	0.0225	M	
^{244}Cm	0.150	M	

[1]S = Sample-based
M = Hanford Defined Waste model-based (Agnew et al. 1997)
E = Engineering assessment-based.

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F5.0 APPENDIX F REFERENCES

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